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the cross-level clamped with its bubble in the middle, it will read altitudes: in order to read declination, elevate the mirror to the co-latitude; clamp it; set the vernier to zero, and the cross-bubble in the middle of its opening.

If the equatoreal be removed to any latitude within its limits, a revision of its adjustments will be unnecessary, as the inclination of the polar axis can be adjusted to the difference of latitude by the graduated arc at the end of the side plate, which is screwed on the moveable one.

The telescope, when in the horizontal position, can be used as a transit instrument, from the equator to within 20 degrees above the north horizon. (If the plane of the mirror be parallel to the declination axis, and perpendicular to the line of collimation, or polar axis, and the declination axis at right angles to the plane of the meridian, the polar axis will be in the last-mentioned plane), which, in equatoreals, is a desideratum.

To prove the flatness of the surface of the mirror, place it at right angles to the line of collimation, by reflection of the wires, and reverse its axis to its Ys, to verify the adjustments; then select an object in the horizon; bring it on the meridian wire; reverse the axis; and if the object be in coincidence with the wire, the mirror is a true plane.

It may be observed, in conclusion, that if the plane of the mirror be parallel to the declination axis, the axis at right angles to the line of collimation and perpendicular to the plane of the meridian, the collimation or polar axis will be in the last-mentioned plane, which, in equatoreals, is a desideratum; and that the telescope, being a fixture, the observer never changes his position in observing stars from the horizon to 20° north of the zenith.*

Stellarum Fixarum imprimis Duplicium et Multiplicium Positiones Mediæ pro Epocha 1830·0, *deductæ ex Observationibus Meridianis, annis* 1822 *ad* 1843 *in Specula Dorpatensi institutis, auctore F. G. W. Struve, fol. pp.* 380 (*Introduc.*, pp. ccliv.), *Petrop.* 1852.

This work, which contains the conclusion of the record of M. Struve's labours on Double Stars at Dorpat, is dedicated by the author "to the memory of the immortal individuals W. Herschel and F. W. Bessel," who contributed in so high a degree by their respective researches to the advancement of stellar astronomy.

M. Struve commences his elaborate Introduction with a brief history of his labours on double stars. When, in the year 1822, he commenced a series of observations of the places of the stars with the meridian circle of Reichenbach, the object which he had in view was twofold. In the first place, he was desirous of deducing the fundamental elements of astronomical science solely from his

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[*] It is intended to send one of these instruments to the Apartments of the Society for the purpose of inspection.

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own observations; secondly, he had in view to determine with precision the mean places of all the double stars hitherto known. To this end he had, on a former occasion, drawn up a catalogue containing the approximate positions of 795 double stars, chiefly discovered by Sir William Herschel, which was published in vol. iii. of the *Dorpat Observations.* Rejecting Herschel's sixth class of stars, the distances of the components of which exceeded 60″, and eliminating those which he had found to be erroneously designated as double stars, there still remained 600 stars whose positions it was required to determine.

Towards the close of the year 1826 M. Struve had succeeded in executing all the observations which were required for the two objects above specified. In the course of these labours, however, he was compelled to enlarge the scope of his undertaking; for, having in the year 1824, obtained possession of a great refractor by Fraunhofer, he found that the double stars contained in the catalogues of Sir William Herschel formed only a small proportion of the number of stars whose duplicity was exhibited in this powerful instrument. He therefore resolved to undertake a careful survey of that portion of the heavens which extends from the north pole to 15° of south declination, with the view of detecting all the double stars down to the eighth magnitude, and within 32″ of mutual distance, which were contained in that region. He achieved this task in the space of three years, and in 1827 he published the *Catalogus Novus*, which contained more than 3000 double stars. Instead of 600 stars, there were now more than 3000, whose absolute places it was required to determine, and the relative positions of whose components it was desirable to ascertain by micrometrical measurement. As it was impossible for him, individually, to accomplish both of these objects, he reserved the execution of the micrometrical measurements to himself, and assigned the observations with the meridian circle to his assistant Preuss. In 1837 he published the *Mensuræ Micrometricæ*, which contained the results of his own labours. The meridional observations were interrupted by the death of Preuss, which occurred in the summer of 1839, when M. Struve was just about leaving Dorpat in order to assume the directorship of the Imperial Observatory of Pulkowa. In 1840 they were resumed at Dorpat by M. Doellen, under the superintendence of M. Mädler, who was now Director of the Dorpat Observatory, and were finally concluded in the year 1843. The meridional observations of Struve, Preuss, and Doellon, are recorded in vols. iv., v., vi., vii., viii., ix., x., and xii. of the *Dorpat Observations.* The last of these volumes was published in the year 1850. The total number of sidereal positions determined by the three observers amounted to 27,600. The object of the present work is to assign the mean positions deducible from these observations.

After a disquisition on the special character of the observations, M. Struve next considers the constants of aberration, nutation, and refraction. With a view to determine the constant of nutation, he caused all the observations of *Polaris* made at Dorpat between the

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years 1822–38, to be carefully reduced. These results formed the groundwork of the well-known investigation of M. Peters. The value of nutation thus deduced was $9''{\cdot}221 \mp 0''{\cdot}018$. The corresponding value of aberration was $20''{\cdot}442 \mp 0''{\cdot}016$.

The mean refraction was deduced from observations of 42 circumpolar stars. Of these the nearest to the pole was *Polaris* itself, and the most distant was 38 *Lyncis*, which, at its upper transit towards the south, had a zenith distance of 20° 50′, and at its lower transit towards the north had a zenith distance equal to 84° 5′. By a discussion of these observations he found the mean refraction to be $\varrho^{\text{I}} = 57''{\cdot}488 \mp 0{\cdot}030$, the barometer being supposed to stand at 332·75 French lines, and the thermometer at 7°·44 Reaumur. Bessel in the *Tab. Reg.* makes the same constant $\varrho = 57''{\cdot}665 \mp 0''{\cdot}041$. Hence the difference between Struve's determination and that of Bessel's is $\varrho^{\text{I}} - \varrho = -0''{\cdot}177 \mp 0''{\cdot}050$. M. Struve seems disposed to conclude, from this considerable discordance, that the constant of mean refraction is to a certain extent dependent on local causes, the origin of which is to be found in the situation of the thermometer, and in the form and dimensions of the observatory.

From 46 observations of the sun's declination made at the solstices, or near those points, in the years 1823–4–5, M. Struve determined the obliquity of the ecliptic for the commencement of the year 1825 to be $= 23° \; 27' \; 42''{\cdot}61 \mp 0''{\cdot}11$.

The apparent diameter of the sun, corresponding to the mean distance of the earth, was deduced from a series of observations extending over four years.

From 219 observations, the vertical semi-diameter of the sun $= 16' \; 0''{\cdot}66 \mp 0''{\cdot}037$.

From 241 transits of the limbs, the horizontal semi-diameter $= 16' \; 1''{\cdot}12 \mp 0''{\cdot}043$.

The difference between the two semi-diameters is, therefore, $0''{\cdot}46 \mp 0''{\cdot}057$. This quantity is sufficiently small to be explicable by errors of observation, but if it really exists, it would seem to indicate a compression of the sun's mass, arising from its rotatory motion.

M. Struve next gives a fundamental catalogue of 109 stars, the places of which emerged from his preceding researches, and after a critical examination of the partial catalogues of the different observers upon which the complete catalogue of the work is founded, he then proceeds to explain the construction of the latter. The whole number of stars is 2874, including the 109 fundamental stars whose positions he had already given. The number of double stars in the Catalogue is 2682. Of these 2511 are contained in the *Catalogus Novus*. The epoch of the Catalogue, as mentioned in the title-page, is 1830·0.

M. Struve next institutes a comparison between the results contained in his Catalogue and those of the earlier Catalogues of Bradley, Piazzi, Lalande, and Groombridge. He finds that his own right ascensions may be completely reconciled with those of Piazzi and Groombridge by applying a correction of $+1''{\cdot}56$ to the situa-

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tion of the meridian mark at Palermo, and a correction of +2″·44 to the meridian mark of Blackheath.

The following probable errors of a single star for the Catalogues of Groombridge, Piazzi, and Lalande, are given by the author:—

	In R.A. ″	In Decl. ″
Groombridge	$0{\cdot}95 \sec\delta$	$0{\cdot}72$
Piazzi	$1{\cdot}50 \sec\delta$	$0{\cdot}97$
Lalande	$3{\cdot}23 \sec\delta : \sqrt{\sigma}$	$2{\cdot}03 : \sqrt{\sigma}$

where σ denotes the number of observations of the same star to be met with in Lalande's Catalogue. Hence, if we denote the error of a single observation of a star in Lalande's Catalogue by unity, we have the following numbers expressive of the relative precision of the position of a star in each of the three Catalogues:—

	Rel. Precis. in R.A.	Rel. Precis. in Decl.
Groombridge	3·1	2·8
Piazzi	2·2	2·1
Lalande	1·0	1·0

After a discussion of the subjects of precession and of the motion of the solar system in space, M. Struve next considers the proper motions of the stars. In reference to this question, he states that his General Catalogue contains 386 stars, which are to be found also in Bradley's Catalogue, as exhibited by Bessel in the *Fundamenta.* Of these 123 are common to Argelander's Catalogue of 560 stars. Sir John Herschel has regretted that no materials exist in the present day for ascertaining the proper motions of telescopic stars. With respect to this question, M. Struve remarks that his Catalogue contains 401 stars, which are visible to the naked eye, and 2473 smaller stars. Of the latter number there are more than 1400, which are of the eighth magnitude, and downwards to the tenth magnitude. M. Struve justly states that his Catalogue, in consequence, offers precious materials for investigating the proper motions of the smaller stars, more especially double stars, by a comparison of its results with observations made at some future epoch. He adds that the preparation of such materials for the use of posterity was the main object which he had in view in determining the absolute positions of telescopic stars.

But, in order to avail himself as largely as possible of all existing materials, M. Struve compared his own Catalogue, not only with Bradley's, but also with the later Catalogues of Piazzi, Lalande, and Groombridge. This operation furnished 1276 additional stars, whose proper motions are indicated with a greater or less degree of certainty.

M. Struve divides the stars of Bradley into two classes. B^a contains 180 stars, which are estimated to have a mean magnitude equal to 3·15, and a mean distance equal to 2·88 (the mean distance of a star of the first magnitude being supposed equal to unity). B^b contains 206 smaller stars, whose mean magnitude and distance are estimated at 5·66 and 7·74 respectively. The remaining

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list of stars R, to which proper motions are assigned, and which have been already stated to amount to 1276 in number, are estimated to have a mean magnitude equal to 7·34, and a mean distance equal to 18·15. The whole number of stars which formed the subject of research amounted, therefore, to 1662, of which there were 734 single stars and 928 double stars.

The following results relative to the proper motions of the three classes of stars above mentioned are given by M. Struve, in which λ signifies the reciprocal of the mean distance of each class:—

	λ	Mean Motion in 30 Years. R.A.	Mean Motion in 30 Years. Decl.
		″ ″	″ ″
From 180 stars, B^a	0·4077	4·64 ∓ 0·52	4·58 ∓ 0·52
— 206 — B^b	0·1326	1·87 ∓ 0·16	1·41 ∓ 0·15
— 1276 — R	0·0612	1·12 ∓ 0·29	0·82 ∓ 0·16

M. Struve closes his researches on the proper motions of the stars by summing up the most important conclusions deducible from them.

The first of these conclusions is, that the proper motions of the different classes of stars are nearly proportional to the distances which have been assigned to them.

Since the angular motions of the different classes of stars thus appeared to be proportional to their distances, M. Struve hence infers that their linear motions are equal. This he found to be true for stars situate in every direction of the heavens, by a comparison of the proper motions of the stars in the different hours of right ascension.

The following table, given by M. Struve, is founded on an examination of the proper motions of the stars of different magnitudes, as deduced by him:—

Mean Motion in 100 Years.

	Isolated Stars.		Binary Stars.	
Magnitude.	R.A.	Decl.	R.A.	Decl.
	″	″	″	″
1·0 M*	34·2	29·0	55·5	47·0
2·0	18·9	16·1	30·8	26·1
3·0	12·4	10·5	20·1	17·0
4·0	8·7	7·4	14·2	12·0
5·0	6·3	5·3	10·2	8·6
6·0	3·7	3·1	6·0	5·1
7·0	2·2	1·8	3·5	3·0
8·0	1·4	1·2	2·3	2·0
9·0	1·0	0·9	1·7	1·5

From the circumstance of the proper motion, exhibiting a gradual diminution, according to the brightness of the star, M. Struve concludes that the stars of the seventh, eighth, and ninth magnitudes, are more especially adapted for investigating the motion of

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* The letter M refers to the magnitudes as estimated in the *Mensuræ Micrometricæ*.

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precession than the brighter classes of stars which are usually employed for that purpose.

With respect to the proper motions of double stars, M. Struve finds that they exceed those of isolated stars in the proportion of 1·624 to 1. He also finds that *those binary stars which revolve more quickly in their orbits are remarkable for their large proper motion.*

M. Struve finally concludes from his researches on this subject, that the proper motion of the sun is greater than $\frac{5}{10}$ths, and less than $\frac{8}{10}$ths of the mean proper motion of 734 single stars, whose positions at different epochs he had compared together.

From the proper motions of the stars, M. Struve passes to the consideration of the relative motions of double stars. These may be subdivided into two classes, viz., those whose constituent bodies have a physical connexion, and those which are merely optically double. M. Struve points out three criteria for deciding the question of the existence of a physical connexion in the case of a double star. First, the revolution of the two bodies around their common centre of gravity furnishes an incontestable demonstration of the existence of a physical connexion. The number of double stars, however, which admit of being subjected to this criterion is very small, hardly amounting to so many as twenty. Secondly, the existence of a physical connexion may be established by the aid of the doctrine of probabilities. In this case, again, the data are so uncertain that little confidence can be placed in the results, even if the principles of the method were absolutely unobjectionable. Lastly, the existence of a common proper motion of the two constituent bodies affords conclusive evidence in favour of their physical connexion. This is a more fertile criterion than the first, and a more trustworthy one than the second; and it has accordingly been very extensively employed by M. Struve.

From a comparison of the absolute and relative proper motions of 208 pairs of stars, M. Struve finds that there are 168, the constituent members of each of which have a common proper motion, and that with respect to the remaining 40 pairs, the relative motions of the components may be explained in each case by the proper motion of one of the two stars. The following table exhibits the results of M. Struve's researches on this subject, the stars being divided into classes depending on the mutual distances of the components.

Class.	Mut. Distance.	No. of Stars.				
		Total No.	Phys. Doub.	Opt. Doub.		
		n	a	b	$\frac{a}{n}$	$\frac{b}{n}$
	″ ″					
I.	0 and 1	9	9	0	1·000	0·000
II.	1 — 2	16	16	0	1·000	0·000
III.	2 — 4	43	43	0	1·000	0·000
IV.	4 — 8	34	32	2	0·941	0·059
V. & VI.	8 — 16	32	28	4	0·875	0·125
VII. & VIII.	16 — 32	34	23	11	0·676	0·324
IX.	32 — 64	21	10	11	0·476	0·524
X.	> 64	19	7	12	0·368	0·632

M. Struve has endeavoured to ascertain by an inductive process founded upon these results, the relative number of physically double stars in the northern hemisphere. The conclusion at which he arrives, by a train of very ingenious reasoning, is expressed by him in the following terms:—"In the northern hemisphere there are about 72500 stars of the magnitudes 1 to 8·5 M. Of these there are 1973 double stars, the extreme distance of the components being supposed equal to 16″, and the limiting magnitude of the companion being estimated at 11·0 M. One in every 36·7 stars is consequently a double star. Of the 1973 recognised double stars, 1702 have a physical connexion, and 271 are merely optically double, or among every seven double stars there are six which have a physical connexion, and only one whose duplicity is merely apparent:—*a physical connexion of the constituent bodies is, therefore, not the exception but the rule.*"

M. Struve remarks that with respect to the brighter classes of stars, the comparatively large number of physically double stars to be met with among them arises from their being so easily resolved, and from the circumstance of their proper motions being so well known. In accordance with this view of the subject, he proceeds to examine more especially the number of physically double stars which are to be found among the class of stars comprised between the first and fourth magnitudes, and he arrives at the conclusion that every fourth of such stars in the heavens is physically double. He even ventures to assert, that, when we have acquired a more complete knowledge of double stars, it will be found that every third bright star is physically double. Applying these considerations to the stars of inferior orders of magnitude, he finally arrives at the following conclusion, which he admits to be of an unexpected character:—"*The fixed stars which are observable in the heavens are either isolated stars like our sun, or systems composed of two, or in some instances of several suns connected together by some physical relation. The number of isolated stars is, indeed, greater, but only three times, perhaps not more than twice the number of compound systems.*"

From the elaborate Introduction to his work, M. Struve proceeds to the various catalogues to which it refers. First, he gives the partial Catalogues, and then the General Catalogue. The latter occupies 58 pages. It exhibits the mean positions in right ascension and declination of 2874 stars, as already stated, reduced to the epoch 1830·0. The quantities of precession in right ascension and declination, corresponding to the epoch of the Catalogue, are also given for each star.

The General Catalogue is followed by a comparison of its results with the earlier Catalogues of Bradley, Lalande, Piazzi, and Groombridge. Next comes a Catalogue containing the mean positions of 175 stars, deduced from observations made by Sablaer at Pulkowa, and reduced to the epoch 1851·0.

As it appeared from subsequent researches that the elements which had been employed in reducing both the partial Catalogues

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and the General Catalogue, required a slight alteration, a table is inserted after the Catalogue above mentioned, containing the small corrections which should be applied to the mean places of the stars in the General Catalogue in consequence of this modification of the elements of reduction.

M. Struve concludes his great work with a comparison of the places of 140 stars which are common to the General Catalogue, and to Argelander's Catalogue of 560 stars, which, like the former, is reduced to the epoch 1830·0.

R. G.

The *Berliner Jahrbuch* for 1856 has recently been published. The Appendix to it contains a translation of Adams' Paper on the Corrections of the Moon's Parallax, as given in the Appendix to the *Nautical Almanac* for the same year. There are also two papers by M. Encke, the Superintendent of the Ephemeris. One of these includes a set of tables for computing the right ascension and declination of a celestial body from its longitude and latitude, and *vice versâ;* the other contains an investigation of the degree of approximation which is attained in calculating the orbit of a comet by the method of Olbers. The Appendix also contains an ephemeris of each of the newly discovered planets either for 1854 or 1855, and a synopsis of the elements of their orbits.

With respect to the drawing of *Saturn* by Mr. Dawes, which appears in the *Monthly Notice* for November 1853, it may be as well to mention that the engraver has made the shading of the belts too deep, and that the dark line upon the inner bright ring should have been omitted (the engraver having been misled by what appeared to be a faint line on the original drawing), as no such indication of a subdivision of the ring is referred to by Mr. Dawes in his account of the appearance of the planet.

On the Aerolites of August 1853.

(*Extract of a Letter from M. Duprez to M. Quetelet, dated Ghent, Aug.* 12, 1853.*)

"During the nights of the 9th and 10th of August, and in a part of the sky which was entirely free of clouds, comprised between NN.E. and S.E., which might be about a sixth, I observed 29 aerolites during the first evening, and 37 during the second. They were distributed as follows:—

	h m		h	9th.	10th.
From	9 50	to	10	3	2
	10 0		11	12	15
	12 0		12	14	20

"Among the aerolites observed on the 9th there is one, the apparition of which has been accompanied by circumstances which

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* Bulletin de l'Académie des Sciences de Belgique.